Autonomous Proprioceptive Terrain Detection for Compliant Rovers

Completed Technology Project (2017 - 2018)

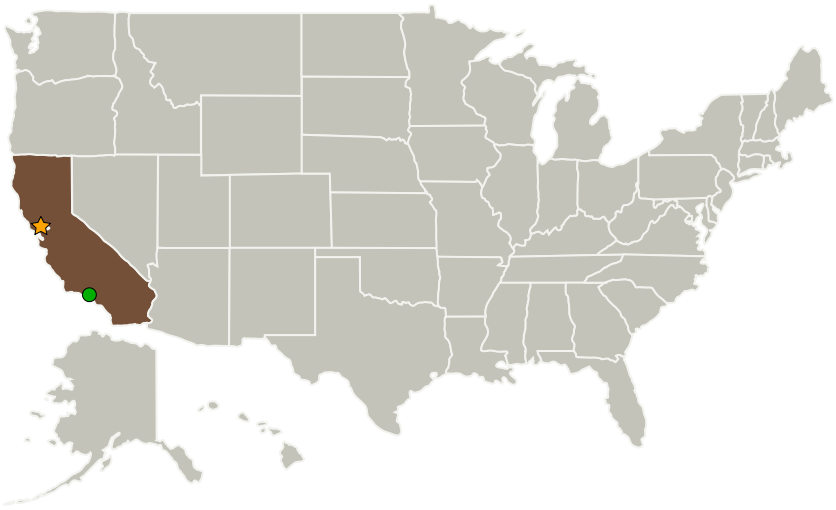
Project Introduction

The initial phase of the project will focus on the identification and adaptation of suitable pseudo-soft or reconfigurable mobility systems (e.g., ARC's SUPERball v2, JPL's PUFFER). In the second phase, we will define a sensor fusion (e.g. UKF) and machine learning algorithm (e.g. MPC, RL) able to characterize terrain features (e.g. slope, substrate, barriers) and evaluate robot performance (e.g. speed, slip, stability) using distributed proprioceptive sensors. As a final step, our terrain detection algorithm will be integrated with existing locomotion control policies and JPL's TARMAC (Terrain Adaptive Reconfiguration of Mobility by Automatic Control) path-planning algorithm to enable autonomous crossing of adverse terrains.

Anticipated Benefits

Potential stakeholders that could benefit from this research include NASA SMD (e.g., Cryosphere program), USGS, and DOD. This type of technology may also be appropriate for other compliant and reconfigurable structures that we are already investigating for earth and space applications, such as deployable heat shields, morphing wings, and other lightweight systems.

Primary U.S. Work Locations and Key Partners



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Center Innovation Fund: ARC CIF

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Organizations Performing Work	Role	Type	Location
Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Project Transitions

October 2017: Project Start

September 2018: Closed out

Closeout Summary: In this project, we analyzed and developed proofs-of-concepts of new types of sensors and algorithms that increase the ability of pseudo-soft and reconfigurable systems to detect properties of their state and their surroundings. These proofs-of-concepts include cable feed and tension sensors, soft and deformable contact sensors, a classifier to detect robot's ground face, an algorithm to improve cable tension measurement, and an LSTM Recurrent Neural Network to detect terrain type using IMU data. We matured these technologies to TRL 3.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VQ

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

Center Innovation Fund: ARC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

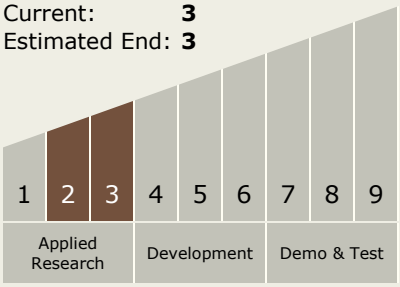
Harry Partridge

Principal Investigator:

Terrence W Fong

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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Technology Areas

Primary:

- TX04 Robotic Systems
  - TX04.2 Mobility
    - TX04.2.5 Robot Navigation and Path Planning

Target Destinations

Earth, The Moon, Mars